2017

Effect of Corn Residue Grazing or Baling on Subsequent Crop Yield and Nutrient Removal

Kristen M. Ulmer
University of Nebraska-Lincoln, kristen.ulmer@unl.edu

Jordan L. Cox
University of Nebraska-Lincoln, jcox7@huskers.unl.edu

Manbir K. Rakkar Rakkar
University of Nebraska - Lincoln

Robert G. Bondurant
University of Nebraska-Lincoln, robby.bondurant@unl.edu

Humberto Blanco-Canqui
University of Nebraska - Lincoln, hblanco2@unl.edu

See next page for additional authors

Authors
Kristen M. Ulmer, Jordan L. Cox, Manbir K. Rakkar Rakkar, Robert G. Bondurant, Humberto Blanco-Canqui, Mary Drewnoski, Karla H. Jenkins, James C. Macdonald, and Rick J. Rasby

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Summary with Implications

A 2-year study evaluated the effect of corn residue baling or grazing on subsequent yields, as well as, nutrient removal by baling at five locations in Nebraska. Three treatments were applied to each field: baled, grazed, and control (no baling and no grazing). Grain and stover yields were measured by hand harvest at maturity. No differences were observed among treatments for corn yield with baled having yields of 234 bu grain / acre, grazed with 239 bu grain / acre and control with 223 bu grain / acre. There was no difference in stover yield among treatments (8,326, 8,135, and 7,945 lb stover DM / acre for baled, grazed, and control, respectively). Results indicate that removing corn residue provides a potential feed resource with no negative impact on grain yield in the short term.

Introduction

The amount of corn residue in the Midwest has increased with increased corn production over the years. Opportunities exist to remove the corn residue from the field for feeding later, or grazing residue in the field. There continues to be questions about the effect of residue removal on corn grain yields in subsequent years. Baling of corn residue means that nutrients associated with residues are removed and require fertilization to be replaced. Because yields are the most important profit indicator for a crop farmer, it is necessary to evaluate possible changes in grain yield with residue removed either by baling or grazing. With corn residue baling, it is important to determine the amount of nutrients removed per acre from the field to determine potential impacts on fertilizer needs for the next planting. The objectives of this 2-year study were to determine how grazing or baling of corn residue affects subsequent grain yield, stover yield, and harvest index at multiple locations across Nebraska, and to calculate the amount of nutrients removed by baling corn residue.

Procedure

Study locations included Ainsworth, Norfolk, Odessa, Scottsbluff, Nebraska City, and Clay Center, all in Nebraska. In year 1 (2013), there were four locations (Ainsworth, Norfolk, Odessa, and Scottsbluff) and in year 2 (2014), two additional locations (Nebraska City and Clay Center) were added. At each location, there were 3 treatments: grazed, baled, and control (no grazing or baling) with 2 replications per treatment per location, except for the Nebraska City field, which had two fields with one field having 2 reps and the other having 3 reps, and the Clay Center location, which had 3 fields with each field having one replication. Treatments were applied to a site in Scottsbluff, but no hand harvest measurements were taken at this site, only baled samples were collected for nutrient analysis. Each field was in a continuous corn rotation, except for the Nebraska City site, which was in a corn-soybean rotation and the Scottsbluff site that was in a corn, dry bean, and sugar beet rotation. The Nebraska City location was rain-fed, Odessa had sub-surface drip irrigation and the other four sites were pivot irrigated. All locations were in no-till, except for the Ainsworth site, which was disked.

Grazed areas were fenced off, and cows were stocked based on corn yield and targeting 50% removal of husk and leaf components of the corn residue. Stocking rate was determined using the University of Nebraska's corn stalk grazing calculator. The baled replications were baled following corn grain harvest by the cooperator. The bales from each replication were counted and weighed. Bales were sampled by taking a core from each bale, and core samples were composited into a bag for each replication. Residue samples were sent to Ward Laboratories (Kearney, NE) for nutrient analysis (N, Ca, P, and K) which was used to determine pounds of N, $CaCO_3$, P_2O_5, and K_2O removed per acre.

Yield data were collected by hand harvest. For continuous corn sites, hand harvest was done once corn reached black layer stage of maturity. Corn plants were cut from 17.5 foot rows (3 rows per replication) at the top of the crown root node. Corn ears were removed, then the ear and remaining plant stover (husk, leaf, and stalk) were weighed separately. Subsequently, three cornstalks and three ears were taken as a subsample from each 17.5 foot bundle for dry matter analysis at 60°C. Ear corn samples were dried in the 60°C oven for 48 hours, then the corn grain was shelled. Cobs and grain went back into the oven separately for another 24 hours or until dry. Cob weights were included in the dry stover yields. Dry matter measurements from the grain and stover were used to calculate corn grain yield and stover (total biomass minus the grain) yield per acre. Harvest index was calculated based on the percentage of dry grain in total dry biomass (grain plus stover).

Soybeans were harvested when they reached about 13% moisture. Hand harvest yield of soybeans consisted of cutting two-17.5 foot rows at the base of the plant at ground level. Rows were bundled and each subsample was dried at 60°C until threshing of the soybeans. At threshing, samples of grain and stover were collected and dried in an oven at 60°C to measure dry matter. Dry matter oven weights for the grain and stover were used to calculate soybean grain yield and stover (total biomass minus the grain) yield per acre for the field.

Table 1. Corn and soybean yield data collected at locations across Nebraska.

	Treatment				
Item	Grazed	Baled	Control	SEM[1]	*P*-value
Corn grain yield, bu/acre[2]	239	234	223	5.09	0.18
Corn stover yield, lbs DM/acre[2]	8,135	8,326	7,945	218	0.59
Harvest Index, %[3]	62.3	61.3	61.0	0.62	0.44
Soybean grain yield, bu/acre[4]	59.1	61.3	62.0	3.46	0.83
Soybean stover yield, lbs DM/acre[4]	3,335	3,807	3,452	288	0.51

[1]SEM = Pooled standard error mean for response variable
[2]Corn grain and stover yield were measured at 4 cooperator sites: Ainsworth, Clay Center, Norfolk, Odessa
[3]Harvest index is the measure of the percentage of corn grain to total biomass (grain + stover).
[4]Soybean grain and stover yields measured only at Nebraska City site

Table 2. Pounds per acre of corn residue (DM basis) removed through baling from each location

	Year			
Cooperator	2013	2014	2015	SEM[1]
Ainsworth	3,461	7,306	5,234	483
Norfolk	4,631	3,873	4,578	483
Odessa	4,247	4,088	1,768	483
Nebraska City[2]	3,431	1,047	4,058	483
Clay Center[3]	—	5,716	4,585	395
Scottsbluff[4]	3,858	5,893	6,681	684

[1]SEM = Pooled standard error mean for response variable
[2]Two fields in rotation each year at NE City.
[3]Clay Center site was not set up until 2014.
[4]Field rotates each year, so same field not used every year.

Table 3. Nitrogen (lb N/ac) removed by baling corn residue across cooperator locations in Nebraska

	Nitrogen Removal				
Cooperator	2013	2014	2015	SEM[1]	*P*-value
Ainsworth	40.7[b]	84.1[a]	46.5[b]	4.40	< 0.01
Norfolk	46.7	45.2	48.7	4.40	0.26
Odessa	32.3[a]	39.2[a]	12.5[b]	4.40	0.02
NE City[2]	32.1[a]	10.9[b]	36.1[a]	4.40	< 0.01
Clay Center[3]	—	65.8	47.0	3.58	0.12
Scottsbluff[4]	30.2[b]	52.5[a]	46.8[a]	6.20	0.05

[ab]Means within row with differing superscripts are different ($P < 0.05$).
[1]SEM = Pooled standard error mean for response variable
[2]Two fields in rotation each year at NE City.
[3]Clay Center site was not set up until 2014.
[4]Field rotates each year, so same field not used every year.

In the spring following year 1, the percentage of ground cover was measured by marking points of ground cover over a 100-foot length.

Data were analyzed using the MIXED procedure of SAS with the response variables being yield, harvest index and nutrient removed. Location (nested within year) and treatment were considered fixed effects.

Results

There were no interactions ($P > 0.11$) between location and treatment for all yield and harvest index analyses, but the main effect of location was significant ($P < 0.01$), as expected. The weather patterns and topographic and soil characteristics among locations across Nebraska made each location unique. Corn grain yields ranged from 152 to 286 bu per acre across locations. However, no differences were observed among treatments ($P = 0.18$) for corn grain yield (Table 1). Most locations were irrigated, therefore, the effects of residue cover on soil moisture may not have been observed, additionally the two years of collection were both wetter than previous years.

There was a difference among treatments ($P < 0.01$) in the amount of ground cover in the spring with grazed having 77.5% cover, baled having 45.8% cover and control having 88.7% cover (SEM = 1.42). This demonstrates that grazing corn residue does not reduce soil cover as much as baling does and that a significant amount of cover remains after grazing.

The baled treatments had numerically greater corn grain yields than control plots. This may be due to more available N and less ground cover enabling the ground to warm up earlier. Nitrogen is needed to degrade C, and with less residue being recycled, a short term bump in yields may be recorded.

There was no difference ($P = 0.59$) in corn stover yield among treatments. Stover yields ranged from 5,236 to 10,656 lb dry matter per acre across locations. There was no difference ($P = 0.44$) in harvest index among treatments (62.3, 61.3 and 61.0 ± 0.62% for grazed, baled, and control, respectively). Harvest index is a measure of the percentage of grain produced relative to plant biomass. The proportion of corn grain is roughly two-thirds of the plant

Table 4. Calcium removed as $CaCO_3$ by baling corn residue across cooperator locations

	$CaCO_3$ Removal[1]				
Cooperator	2013	2014	2015	SEM[2]	*P*-value
Ainsworth	29.0[b]	59.3[a]	43.5[ab]	6.06	0.04
Norfolk	60.1	51.2	54.9	6.06	0.32
Odessa	31.3[a]	27.0[a]	10.6[b]	6.06	< 0.01
NE City[3]	44.3[a]	11.5[b]	34.0[a]	6.06	< 0.01
Clay Center[4]	—	46.2	37.6	4.95	0.44
Scottsbluff[5]	33.8	53.4	58.9	8.58	0.33

[ab]Means within row with differing superscripts are different ($P < 0.05$).
[1]Nutrient removed by baling in lbs / acre
[2]SEM = Pooled standard error mean for response variable
[3]Two fields in rotation each year at NE City.
[4]Clay Center site was not set up until 2014.
[5]Field rotates each year, so same field not used every year.

Table 5. Phosphorus removed as P_2O_5 by baling corn residue across cooperator locations

	P_2O_5 Removal[1]				
Cooperator	2013	2014	2015	SEM[2]	*P*-value
Ainsworth	7.89	8.77	6.62	0.977	0.13
Norfolk	4.33	3.72	3.30	0.977	0.29
Odessa	3.31	3.49	1.38	0.977	0.19
NE City[3]	2.72[a]	0.75[b]	2.93[a]	0.977	0.05
Clay Center[4]	—	6.90	5.26	0.798	0.39
Scottsbluff[5]	4.17	4.71	3.11	1.38	0.65

[ab]Means within row with differing superscripts are different ($P < 0.05$).
[1]Nutrient removed by baling in lbs / acre
[2]SEM = Pooled standard error mean for response variable
[3]Two fields in rotation each year at NE City.
[4]Clay Center site was not set up until 2014.
[5]Field rotates each year, so same field not used every year.

Table 6. Potassium removed as K_2O by baling corn residue across cooperator locations

	K_2O Removal[1]				
Cooperator	2013	2014	2015	SEM[2]	*P*-value
Ainsworth	70.1[c]	204[a]	157[b]	25.7	< 0.01
Norfolk	54.4	73.9	73.0	25.7	0.29
Odessa	88.5[ab]	136[a]	32.4[b]	25.7	< 0.01
NE City[3]	46.6[b]	71.6[a]	22.0[c]	25.7	< 0.01
Clay Center[4]	—	249	199	21.0	0.31
Scottsbluff[5]	95.4	171	285	36.3	0.10

[abc]Means within row with differing superscripts are different ($P < 0.05$).
[1]Nutrient removed by baling in lbs / acre
[2]SEM = Pooled standard error mean for response variable
[3]Two fields in rotation each year at NE City.
[4]Clay Center site was not set up until 2014.
[5]Field rotates each year, so same field not used every year.

aboveground biomass produced, but ranged from 55.1 to 66.0% across locations. The Norfolk location had the most variable harvest index due to the site receiving hail in 2014.

Soybean grain yield did not differ ($P = 0.83$) for grazed, baled, and control having grain yields of 59.1, 61.3, and 62.0 bushels per acre, respectively (Table 1). Soybean stover produced did not differ ($P = 0.51$) between treatments (3,335, 3,807, and 3,452 lb dry mass per acre, respectively).

Based on yield data, there is no evidence that baling, grazing, or leaving residue will change grain yield in the short term. However, Drewnoski et al. (2015 Nebraska Beef Report, pp. 53–55) observed that in the long term, over a 10-year period, grazing corn residue at UNL recommended rates did not impact the subsequent corn yields but improved soybean yields of field's managed in a corn-soybean rotation.

Among the six cooperator sites over the three years of baling, the average amount of corn residue removed per acre by baling ranged from 1,047–7,306 lbs per acre with the average removed being 4,390 ± 1, 577 lb DM per acre (Table 2). There was substantial variation among cooperators in the amount of residue removed relative to the total residue produced per acre with a range from 15–80%, suggesting that there were considerable differences in baling methods.

Nutrient removal from baling corn residue means that nutrients will eventually need to be replaced with fertilizer. Nitrogen, P, K, and Ca are four major nutrients that plants need for growth. The concentration of N in the baled residue ranged from 0.68–1.18% with an average of 0.96 ± 0.162%. The concentration of Ca in the bales ranged from 0.24–0.53% with an average of 0.37 ± 0.09%. The concentration of P in the baled residue ranged from 0.04–0.19% with an average of 0.08 ± 0.033% P and the K in the baled residue averaged 1.11 ± 0.45% with a range of 0.51 to 1.91% K.

The amount of N removed by baling corn residue is listed in Table 3 and varied across location ($P < 0.01$) ranging from 10.9 to 84.1 lb N /acre with an average of 42.3 ± 17.3 lbs removed per acre. The amount of Ca (reported as $CaCO_3$ equivalents) is shown in Table 4 and ranged from 10.6 to 60.1 lb $CaCO_3$/acre with an average of 37.3 ± 16.3 lbs $CaCO_3$ /acre. Phosphorus removal (reported as P_2O_5 equivalents) is shown in Table 5. The amount of P removed ranged from 0.75 to 8.77 lbs P_20_2 /ac with an average of 4.31 ± 2.18 lbs P_2O_5. Lastly, K removal (reported as K_2O equivalents) is shown in Table 6 with the range among locations being 22 to 285 lb K_2O/ acre.

Conclusions

Results indicate that, in the short term, removing corn residue through grazing or baling provides a potential feed resource with no negative impact on grain yield or harvest index. However, baling results in more loss of ground cover than does grazing. Baling also results in removal of N, P, K, and Ca. Nutrient removal by baling varied considerably among cooperators and among year within cooperators. These data demonstrate that it is important to weigh and sample bales to have an accurate estimate of the amount nutrients that need to be replaced after baling of corn residue.

Kristen M. Ulmer, graduate student

Jordan L. Cox, graduate student

Manbir K. Rakkar, graduate student

Robert G. Bondurant, research technician

Humberto Blanco-Canqui, associate professor, Agronomy and Horticulture, Lincoln

Mary E. Drewnoski, assistant professor, Animal Science, Lincoln

Karla H. Jenkins, associate professor, Panhandle Research and Extension Center

James C. MacDonald, associate professor, Animal Science, Lincoln

Rick J. Rasby, professor, Animal Science, Lincoln